7. SITE 377: MEDITERRANEAN RIDGE CLEFT

Shipboard Scientific Party[1]

SITE DATA

Position: 35°09.25′N, 21°25.86′E

Water Depth (sea level): 3718 corrected meters, echo sounding

Bottom Felt at: 3719 meters, drill pipe

Penetration: 263 meters

Number of Holes: 1

Number of Cores: 4

Total Core Recovered: 8.2 meters

Percentage Core Recovery: 82.0%

Oldest Sediment Cored
Depth subbottom: 263 meters
Nature: Mudstone
Age: Middle Miocene

Basement: Not reached

Principal Results: Site 377 (Figure 1) was located in a cleft on the Mediterranean Ridge, previously drilled by Leg 13 (Site 126). Its objective was to penetrate further a pre-Messinian section known to be present beneath the Quaternary valley-fill. The hole penetrated 100 meters into the pre-Messinian, but was terminated at 263 meters subbottom because of an unproductive drilling rate. In this hole a middle Miocene marl was encountered underlain by a flysch-like terrigenous sequence of siltstones, sandstones, and dark gray mudstones. These sediments were deposited on a continental rise or in a basinal setting, prior to their uplift by pre-Quaternary tectonic deformation. The poorly preserved benthic faunas were nevertheless, sufficient to demonstrate a bathyal depth here in the middle Miocene.

BACKGROUND AND OBJECTIVES

Background

Since the proposed drill site on the Eratosthenes Seamount was not feasible due to technical reasons, we decided to invest a portion of the ship time still available to us, in an attempt to recover pre-Messinian sediments at the Leg 13 Site 126. This had been discussed as a potential objective during the deliberations of the Mediterranean Advisory Panel and it was again proposed, in the light of our experience at Site 375. The suggestion was unanimously supported at a meeting of the shipboard scientists.

Site 126 was located in a cleft in the Mediterranean Ridge (Figure 2), where the Serravallian marls crop out under the Quaternary valley-fill (Figure 3). Leg 13 drilling at this site revealed the presence of more than 100 meters of valley-fill; thick enough to stabilize our bottom-hole assembly. This previous drilling failed to penetrate more than a few meters into the Serravallian marlstones because of a wrongly chosen drill bit.

Objectives

It was believed that deep-sea drilling technology had improved sufficiently during the intervening 4-1/4 yr since Leg 13, that we would be able to penetrate pre-Messinian strata with relative ease. Our strategy was therefore to stay on location until the bit wore out, as long as the sedimentation rate was slow and the penetration rate was high enough to permit us a glimpse of the Paleogene history of the Mediterranean Ridge. Otherwise, we should proceed to the Aegean Sea for our Neogene objective there.

A second objective was to try to clarify a question on the genesis of the Mediterranean Ridge. It had been suggested that the ridge was a giant post-Messinian olistostrome (Mülder, 1973) or a lower to middle Miocene sliding nappe (Biju-Duval et al., 1974). These ideas were proposed mainly on the basis of the "cobblestone topography," the numerous diffraction patterns, and the nature of the southern boundary of the Mediterranean Ridge on seismic profiles. Leg 13 drilling at Sites 125 and 126 proved that there was normal superposition of strata in the Plio-Quaternary sediments. Seismic profiles interpreted in light of the drilling results also suggested a normal superposition down to the Serravallian. We hoped that deeper penetration would finally settle the question of whether the ridge was an olistostrome.

OPERATIONS

Site Approach

On 15 May *Glomar Challenger* approached Site 377 from the east on a 268° course with a speed of 7.5 knots. The vessel arrived at a prearranged turning point at 0911 LCT, where she began to follow a Leg 13 *Glomar Challenger* profile to approach the site (Figure 4). At 0936 LCT the vessel slowed to 6 knots

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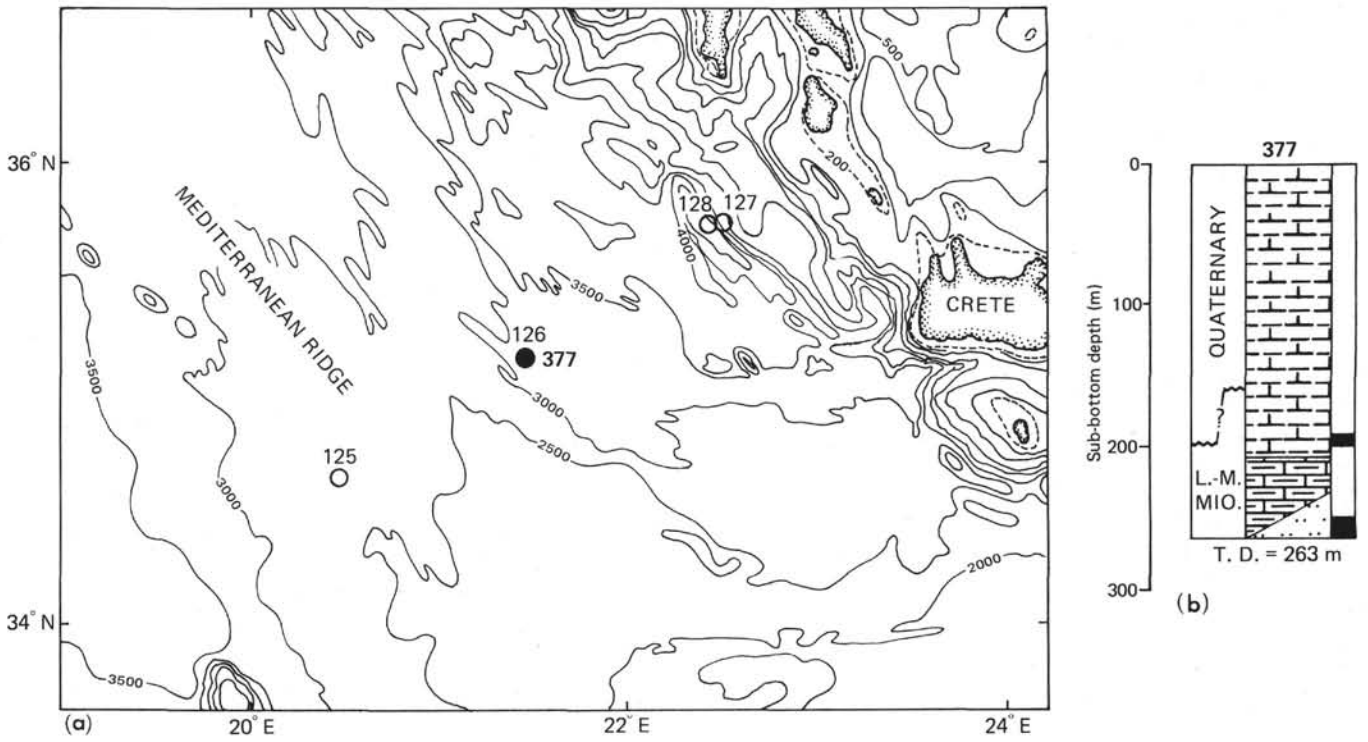

Figure 1. *(a) Site location map (depth contours in meters); and (b) generalized hole summary.*

to permit the retrieval of the seismic gear. An adjustment of the course to 260° was made after the 0948 LCT satellite fix position was received. At 1035 LCT, the speed was further reduced to 2 knots to facilitate the approach. The vessel passed over the target at 1045 LCT and a 16-kHz beacon was dropped. The depth was recorded at 1931 fathoms (PDR uncorrected), or 3128 meters (corrected) from the rig floor. Site 377 is located within a large submarine cleft, between the summit of the Mediterranean Ridge to the west and the Helenic Trench to the east. Its location is very near Site 126 of Leg 13; only 0.472′ off to the south and 0.227′ to the east.

Drilling Program

The vessel was positioned at 1130 LCT, and the crew started to assemble the drill string. The string touched bottom at 1835 LCT at 3719 meters depth, and penetrated easily the Quaternary valley-fill down to 161 meters subbottom. Two hard layers were encountered at 47 meters and 86 meters subbottom, respectively. There was a drastic change in torque at 161 meters subbottom and a great reduction in rate after the drill string penetrated into the pre-Messinian sediments.

At 2320 LCT the first core was brought on deck. The core contained mainly Quaternary sediments, but with a piece of hard marl of middle Miocene age. Drilling proceeded very slowly throughout the night, penetrating at a rate of about 5 m/hr. Interbeds of very fine-grained sandstones were encountered indicative of higher sedimentation rates. On the morning of 16 May, it became obvious that the available ship time would not permit us to drill deep enough to attain our main objective. Since it was more important to use the remaining time for the Aegean site, it was decided to terminate drilling at 1200 LCT at 263 meters subbottom after Core 4 was cut. This last core was retrieved at 1915 LCT, as the drill collar was being raised on deck. At 2030 LCT, the vessel departed for Site 378. Table 1 presents a summary of the limited coring at Site 377.

LITHOLOGY

At Site 126, Quaternary sediments were encountered in Cores I to III and the Quaternary/Miocene disconformity at a subbottom depth of about 109 meters (at Site 126A at 65.9 meters) was not recovered. The first core at Site 377 recovered this boundary at a subbottom depth of about 190 meters. The contact however was obviously a drilling artifact and the change in lithology actually occurred at 161 meters as evidenced by a change in drilling characteristics. The Quaternary sediments comprise lithologic Unit I. The bottom of Sample 1-2, 145-150 cm and the related core catcher is of middle Miocene age. Because of the lithologic difference it is regarded as a separate unit (Unit II). Unit III encompasses Cores 2 to 4 (see Table 2).

Unit I

Unit I (Core 1, Sections 1 and 2, to 142 cm) includes three graded sand units set in a fine-grained background sediment of nannofossil marl with a layered sapropelic sequence. The above overlie a slumped sediment sequence (Sample 1-2, 118-142 cm).

Two graded units occur in the upper part of Section 1 (45-62.5 cm and 62.5-105.5 cm). Laminated quartz-foraminiferal or pteropod-foraminiferal sands grade

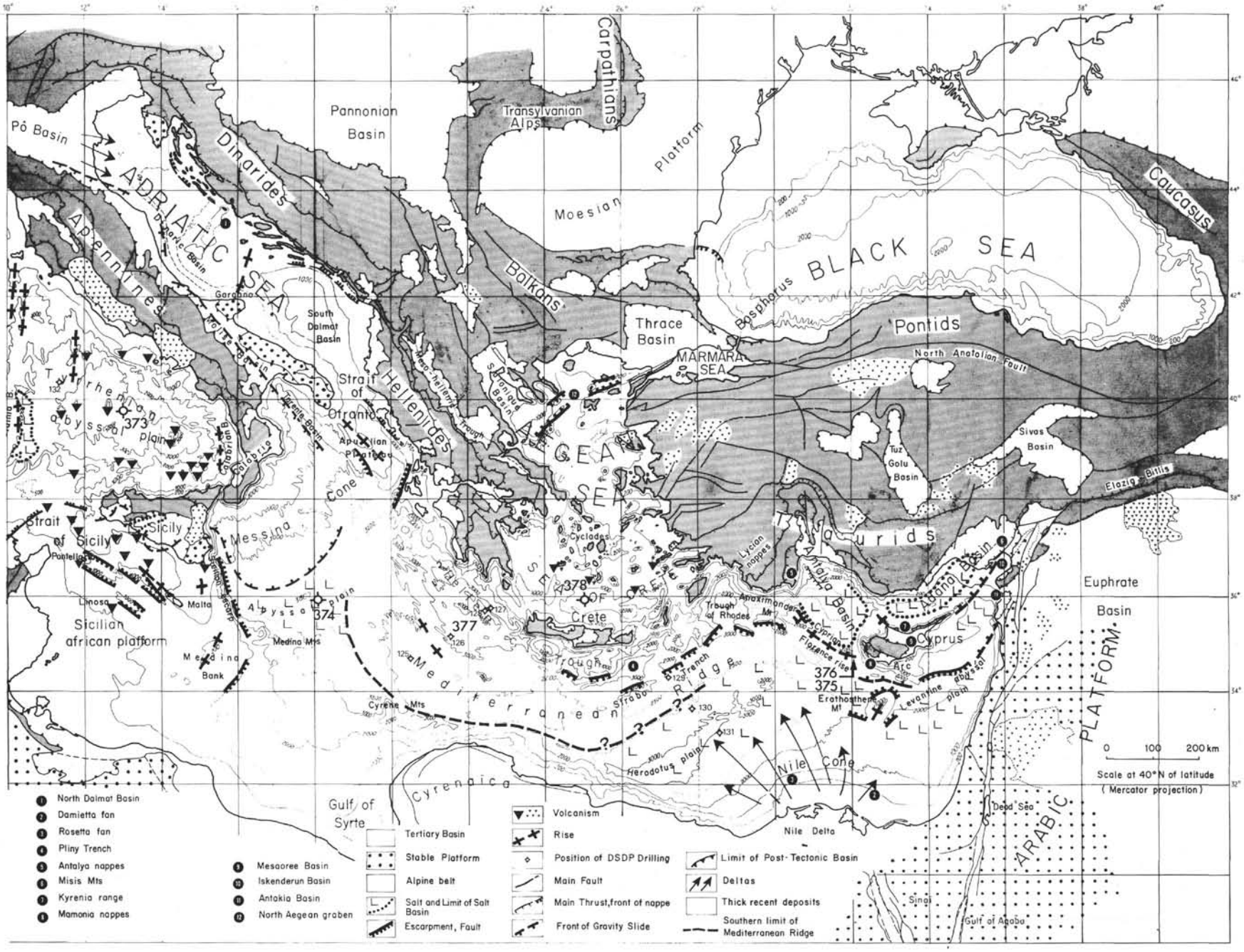

Figure 2. *Structural sketch map of the eastern Mediterranean from Biju-Duval et al. (1974).*

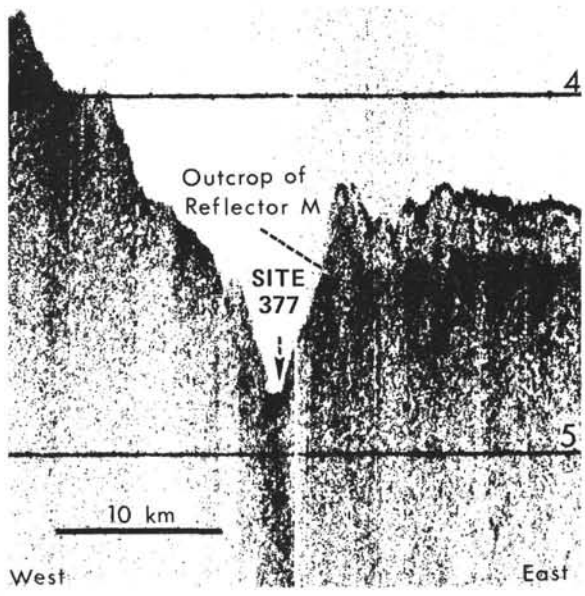

Figure 3. *Leg 13* Glomar Challenger *profile over Site 377/126.*

upwards into light olive-gray nannofossil marls. The graded unit in Section 2 (41.5-111.5 cm) comprises pteropod-foraminiferal sand to greenish-gray nannofossil ooze, containing near the base many sand-sized components and mud pebbles of sapropel material. These graded units are interpreted as turbidites.

The sediment in which the turbidites are set is yellowish-brown to greenish-gray sandy foraminiferal-nannofossil marl and dark greenish-gray pyrite-rich nannofossil marl, interbedded with olive-gray to grayish-olive sapropel layers (foraminiferal marls). Clay makes up about one-third of the bulk mineralogy and illite is the dominant clay mineral. The boundaries between the background sediments and the bases of the turbidites is sharp with a change of color from light greenish to light brown and gray hues.

The base of Unit I consists of 24 cm of deformed variegated sandy foraminiferal ooze and marl, which is probably a slumped sequence. It contains mud pieces derived from Unit II below.

Unit II

This unit comprises greenish-gray nannofossil marls of middle Miocene age which were recovered from the interval 142 to 150 cm in Core 1, Section 2 and in the core catcher of Core 1. The unit is distinguished from Unit I primarily on its age difference, but also on color, lithification, and its less deformed appearance.

Unit III

This is a sequence of nannofossil and silty mudstone with interbedded calcareous silt to sandstones, which are poorly graded. Its color is dark, ranging from greenish-gray to greenish-black. Some of the pieces show bedding features with inclination of about 30°. The greenish-black mudstones are organic-rich. Core 4 consisted entirely of a drilling breccia and cuttings. Clay minerals make up three-quarters of the bulk mineralogy and these are dominated by smectite and kaolinite.

GEOCHEMICAL MEASUREMENTS

Interstitial Water

Measurements of *p*H, alkalinity, salinity, chlorinity, and Ca and Mg content were made for a single sample only onboard ship. This is insufficient to warrant description here.

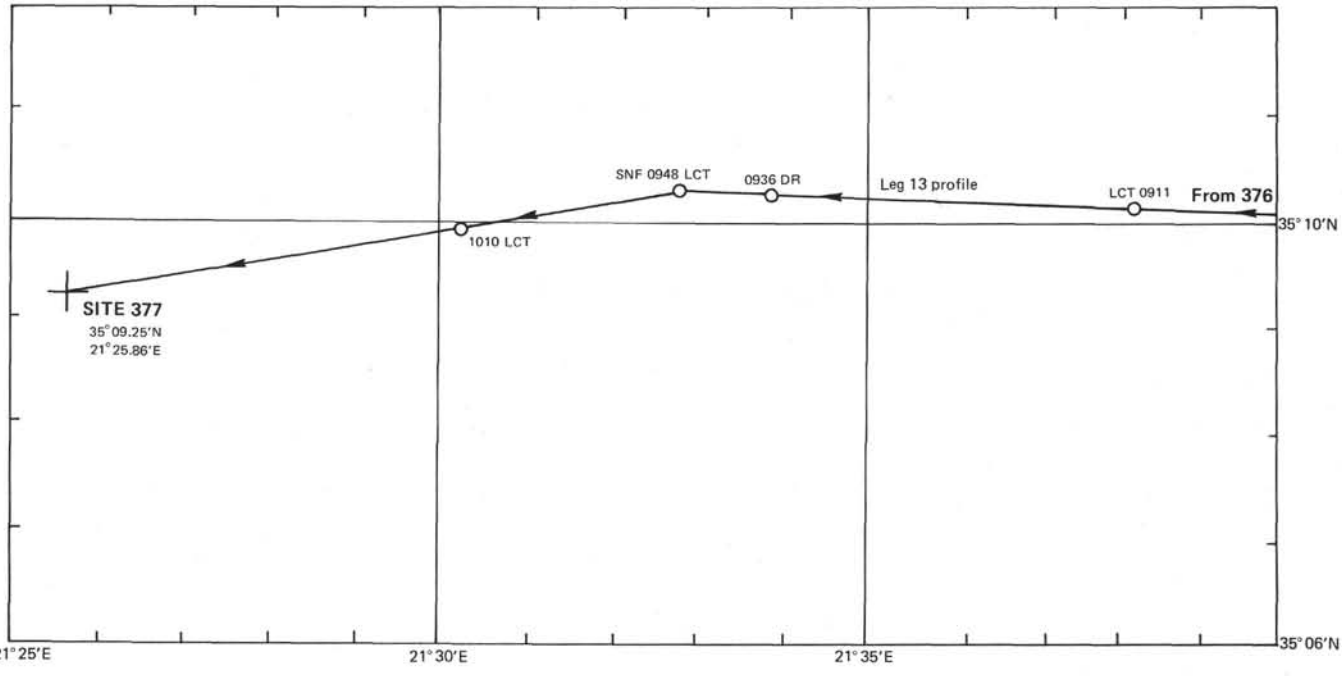

Figure 4. *Site approach, Site 377.*

TABLE 1
Coring Summary

Core	Date (May 1975)	Time	Depth from Drill Floor (m)	Depth Below Sea Floor (m)	Cored (m)	Recovered (m)	Recovery (%)
1	15	2310	3909.5-3912.5	190.5-193.5	3.0	2.7	90
2	16	0845	3968.5-3969.5	249.5-250.5	1.0	0.6	60
3	16	1030	3976.0-3979.0	257.0-260.0	3.0	1.9	63
4	16	1915	3979.0-3982.0	260.0-263.0	3.0	0.5[a]	17
Total					10.0	5.7	57

[a]0.5 meter core recovered; the remaining liner was filled with cuttings.

TABLE 2
Lithologies at Site 377

Unit	Lithology	Cores	Subbottom Depth (m)	Thickness (m)	Age
I	Nannofossil marls with graded quartz-foraminiferal sands	1	0-161	161	Quaternary
II	Nannofossil marlstone	Base of 1 and core catcher	161-230 (?)	70?	Middle Miocene
III	Nannofossil and silty marlstones with calcareous silt to sandstones	2-4	230(?)-263	33?	Middle to early Miocene

TABLE 3
Site 377 Carbonate and Organic Carbon Determinations

Sample (Interval in cm)	Shipboard Carbonate "Bomb" Values (%)	Shorebase (Munich) Total Carbonate (%)	Dolomite (%)	Organic Carbon (%)
1-1, 65-67	–	51	Trace	0.3
1-1, 81-82	45	–	"DL"	–
1-1, 104-106	–	68	T	0.16
1-1, 130-131	30	–	"DL"	–
1-1, 140-150	–	–	–	3.85[a]
1-1, 149-150	–	50	T	2.9
1-2, 10-11	–	34	T	4.1
1-2, 28-29	–	37	11	3.5
1-2, 57-58	36	–	"DL"	–
1-2, 97-98	–	46	T	3.5
1-2, 109-111	–	50	T	0.3
2-1, 105-106	50	52	T	0.4
2-1, 119-120	34	–	–	–
3-1, 148-149	0	–	–	–
3-2, 19-23	–	23	0	0.4
3-2, 129-130	0	–	–	–
4-3, 140-142	–	13	T	1.05

Note: T = Trace; "DL" = remarks on "bomb" measurement — probably a trace of dolomite.
[a]Shipboard measurement.

Carbonate Content

For all the major lithologies, carbonate content was determined by the carbonate bomb method. In addition, further determinations were made onshore and organic carbon values were also determined (see Table 3). The Pleistocene sapropel layers in Core 1 are clearly seen (>2.0% organic carbon.)

PHYSICAL PROPERTIES

All of the physical properties were determined in sediment consisting of undeformed nannofossil marl and ooze of varying foraminiferal content, and having layers of interbedded quartz, foraminiferal, and pteropod sands.

Water content, bulk wet density, and porosity were determined from syringe samples and bulk wet density and porosity were determined from gamma ray attenuation measurements (Tables 4 and 3 of Appendix VI, respectively). The gamma ray attenuation record indicates substantial mechanical disturbance and the maximum bulk wet density value of 1.92 g/cc occurs in only one 15-cm section of the core, the balance of the core having densities ranging from 1.59 to 1.81 g/cc. This is in reasonable agreement with the two gravimetrically determined density measurements (1.78 and 1.90 g/cc). A single thermal conductivity measurement (2.986 mcal/cm sec) was made at 192.77 meters subbottom (Table 7 of Appendix VI).

BIOSTRATIGRAPHY

Summary

Site 377, located close to the Leg 13 Site 126, recovered only four discontinuous cores from subbottom depths between 190.5 and 263 meters (see Figure 5).

Mixed assemblages of Quaternary age were recorded in Core 1, Sections 1 and 2. A few fragments of pteropods were found in Core 1.

In the core catcher of Core 1, two kinds of sediment were recovered, belonging, respectively, to the Quaternary and the middle Miocene.

The sediments of Core 2 (249.5 to 250.5 m subbottom) were very poor in microfossils. The planktonic foraminifers and nannofossils indicate a middle to early Miocene age.

Core 3 and the drilling breccia of Core 4 were practically barren of foraminifers. A few species of nannoplankton indicate a lower-middle Miocene age.

Benthic foraminifers are generally absent except in the Quaternary.

Nannofossils

Quaternary

In Core 1 (190.5-193.5 m subbottom), a mixed assemblage of Pleistocene age is present (*Emiliania*

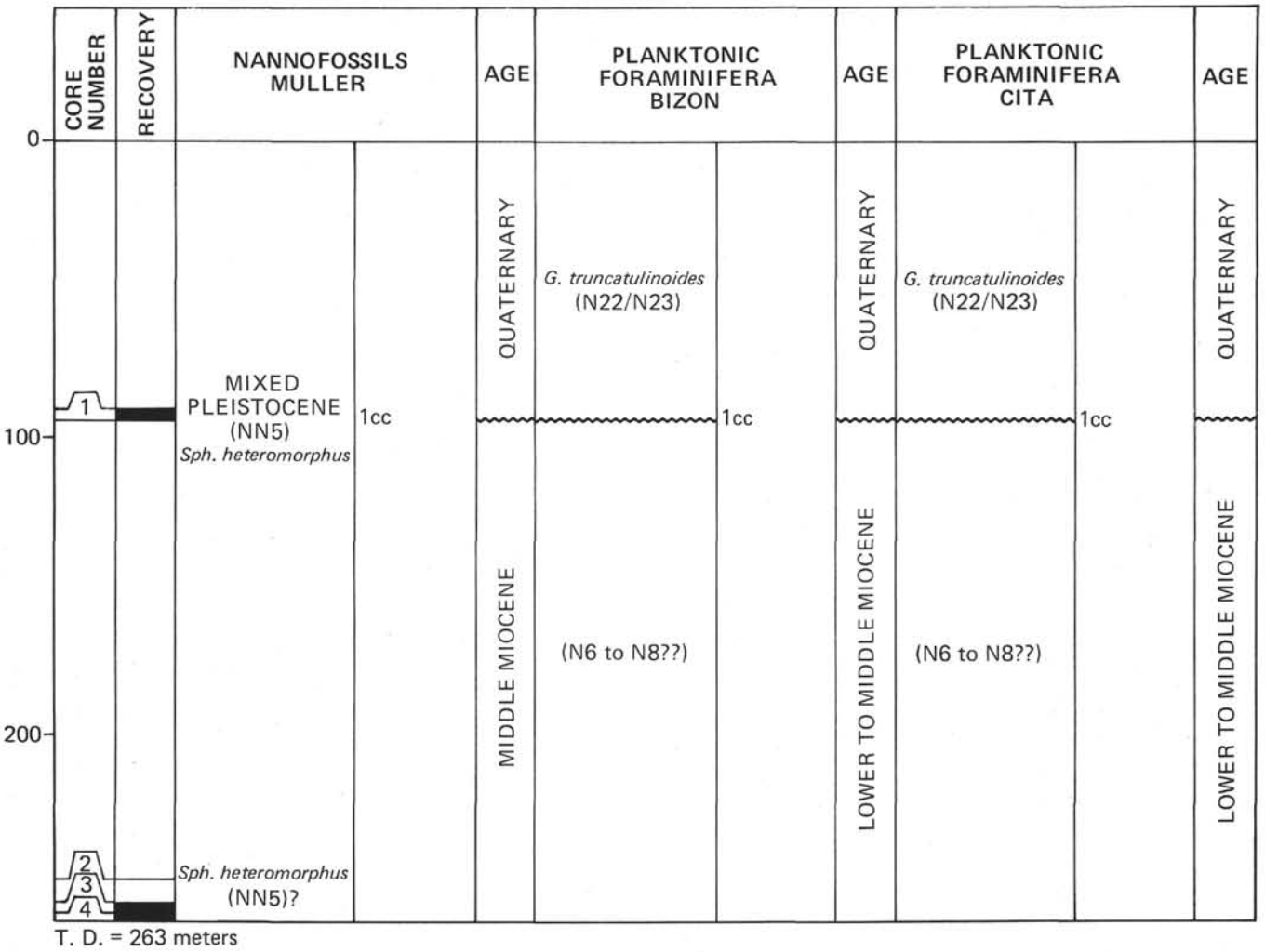

Figure 5. *Relative planktonic microfossil zonations, Site 377.*

huxleyi and *Pseudoemiliania lacunosa*). The sediments are rich in well-preserved nannoplankton. In Sample 1, CC, clay and sandy clay were recovered. The sandy clay still contains nannofossils of the Pleistocene, while the assemblage of the clay is lower to middle Miocene.

Miocene

A gray pebble at 126 cm in Core 1 contains the nannoplankton assemblage of the *Sphenolithus heteromorphus* Zone (NN 5) with *Cyclococcolithus macintyrei, Reticulofenestra pseudoumbilica, Helicosphaera carteri, Sphenolithus heteromorphus* (rare), *Sphenolithus abies,* and *Discoaster exilis.* The coccoliths of this sample are slightly etched, while the discoasters are overgrown. The same assemblage was found in the clay of Sample 1, CC.

Samples 2, CC (249.0-260.0 m subbottom), 3-1, 120-121 cm, and 3, CC are poor in well-preserved nannoplankton. The assemblages consist of *Cyclococcolithus macintyrei, Reticulofenestra* cf. *pseudoumbilica, Cyclococcolithus floridanus, Coccolithus pelagicus, Discoaster exilis, Coccolithus abisectus,* and few specimens of *Sphenolithus heteromorphus.* Reworked species from the Cretacceous and Eocene-Oligocene were found. Probably these samples also belong to the *Sphenolithus heteromorphus* zone. The content of nannofossils shows a decrease down hole.

Planktonic Foraminifers (Cita)

Quaternary Valley-Fill

Core 1, with two sections recovered, contained a variety of sediments, including marls, marl oozes, foraminiferal sands, and sapropels.

Seven samples were examined from this core, including three samples of three different lithologies present in the core catcher and the remainder mostly from sapropel layers.

The samples from the thick sapropel at 1-1,140 cm were very rich in foraminifers but the assemblage was not highly diversified and included *Globigerinoides ruber, G. sacculifer, Orbulina universa, Globigerina bulloides, G. quinqueloba, Globorotalia scitula* and rare specimens of *G. inflata.* Pyrite fillings were common. The sapropel sample at 1-2,13 cm was very rich in carbonaceous and organic matter. The foraminiferal fauna includes *Globigerina eggeri, G. bulloides, Globorotalia inflata, G. scitula, Globigerina pachyderma,* etc.

The sapropel sampled at 1-2,30 cm also yielded spores and foraminifers with pyrite test fillings, indicating reducing conditions at the sediment/water interface.

The foraminiferal sand sampled at 1-2,103 cm was rich in fragments of pteropods. It was also extremely rich in very large, rounded specimens of *Globorotalia inflata* and of *Orbulina universa*, clearly sorted by size. Pyrite is common. The new observational data confirm those obtained at DSDP Site 126 where the shipboard party concluded that: "the presence of sand layers, in which the coarse fraction is comprised almost entirely of foraminiferal tests and authigenic minerals, indicates that pelagic sedimentation here was now and then interrupted by redeposition and reworking in nearbottom current regimes." The three different lithologies sampled in the core catcher of Core 1 include: (a) a gray marl yielding a Pleistocene foraminiferal fauna, (b) a semi-indurated sandy layer light brown in color, yielding abundant shards of volcanic glass, fragments of pteropods, pyrite, and planktonic foraminifers of N 22 zonal age. (c) an olive-gray marlstone (see below).

The Subcropping Miocene Strata

The olive-gray marlstone yielded a few, badly preserved foraminiferal tests including *Orbulina universa* and *Globigerina* cf. *praebulloides* . The occurrence of the former taxon indicates an age which cannot be older than early Serravallian.

Core 2 was almost nonfossiliferous, as far as the samples examined are concerned. Almost no sand-size fraction was present in the sediment. Some mica flakes, a few quartz grains, some pyrite concretions, rare plant debris and fragments of organic matter appeared in Sample 2-2,125-127 cm. A few, badly preserved foraminifers occurred in Sample 2, CC. A similar poorly preserved fauna was found in the Serravallian at Site 126.

The samples investigated from Core 3 were entirely barren. The absence of foraminifers is consistent with the recorded absence of carbonates in that core.

Planktonic Foraminifers (Bizon)

Core 1, Sections 1 and 2 belong to the Quaternary, . *Globorotalia truncatulinoides* Zone. *Globorotalia truncatulinoides* (left and right coiling) and *Globorotalia inflata* etc. were recorded in Sample 1-2,106 cm. Some reworked species from the lower to the middle Miocene were also observed (e.g., *Cassigerinella*).

Sample 1, CC was practically barren. Only *Orbulina saturalis, Globoquadrina altispira,* and *Globigerina angustiumbilicata* were observed. This sediment cannot be older than middle Miocene.

One sample from Core 2 Section 1, 110 cm contained a small-sized planktonic foraminiferal microfauna. *Cassigerinella chipolensis* and *Flobigerina angustiumbilicata* were recorded. This assemblage cannot be younger than Langhian or older than lower Miocene (*Cassigerinella* has not been recorded in the Mediterranean area in the Oligocene or the Serravallian).

Benthic Foraminifers

The rare, but well preserved, Pleistocene benthic foraminifers at this site consist of species which indicate a water depth in at least the upper mesobathyal zone (>1000-1300 m): *Articulina tubulosa, Eponides pusillus,* and *Pullenia quinqueloba* .

The middle and lower Miocene sequence is barren of benthic foraminifera, except for Sample 1, CC which contains a poor fauna dominated by *Anomalina cicatricosus,* a mesobathyal form.

SEDIMENTATION RATES

The available data at Site 377 are such that a sedimentation rate curve cannot be drawn. The only known boundary is that between Pleistocene and probable lower Serravallian sediments at the base of Core 1 (193.5 m). This is a major hiatus representing at least 13.5 m.y. It is likely that the hiatus was in fact reached at 161 meters subbottom, where a marked change in drilling rate occurred. Consequently, all that can be said is that the Quaternary is at least 161 meters thick at this location and that its sedimentation rate must be greater than 5 cm/10^3 yr.

Estimates of the age of the basal sediment cored at the terminal depth of ~263 meters, range from early to lower middle Miocene (N6 to NN5). This range, together with the presence of the major hiatus, make it impractical to quote even an average sedimentation rate for the sequence.

CORRELATION OF SEISMIC REFLECTION PROFILES WITH DRILLING RESULTS

Site 377 was located in the same cleft of the Mediterranean Ridge as Site 126 of Leg 13 (Figure 6). The contact between the Quaternary ponded sediments and the buried flank of the valley, which was encountered at 161 meters subbottom, cannot be precisely estimated by seismic profiling because the flank on the profile is marked by a diffraction hyperbola. No reflectors are visible below.

SUMMARY AND CONCLUSIONS

Site 377 was located in a cleft in the Mediterranean Ridge at 35°09.25′N, 21°25.86′E in 3718 meters water depth. The drilling objectives were twofold:

1) To obtain a pre-Messinian sedimentary record as far back in time as possible,

2) To gather information on the tectonics of the Mediterranean Ridge.

The hole was drilled through a Quaternary valley-fill and penetrated 100 meters into a Miocene flysch-like formation. We decided to terminate drilling at 263 meters subbottom for the following reasons: (1) A more prolonged attempt for deep penetration would have prevented us from drilling the Aegean Site 378; (2) The drilling rate was slow, and the formations hard, and we did not expect to be able to penetrate very deep in this hole with the expected life of the drill

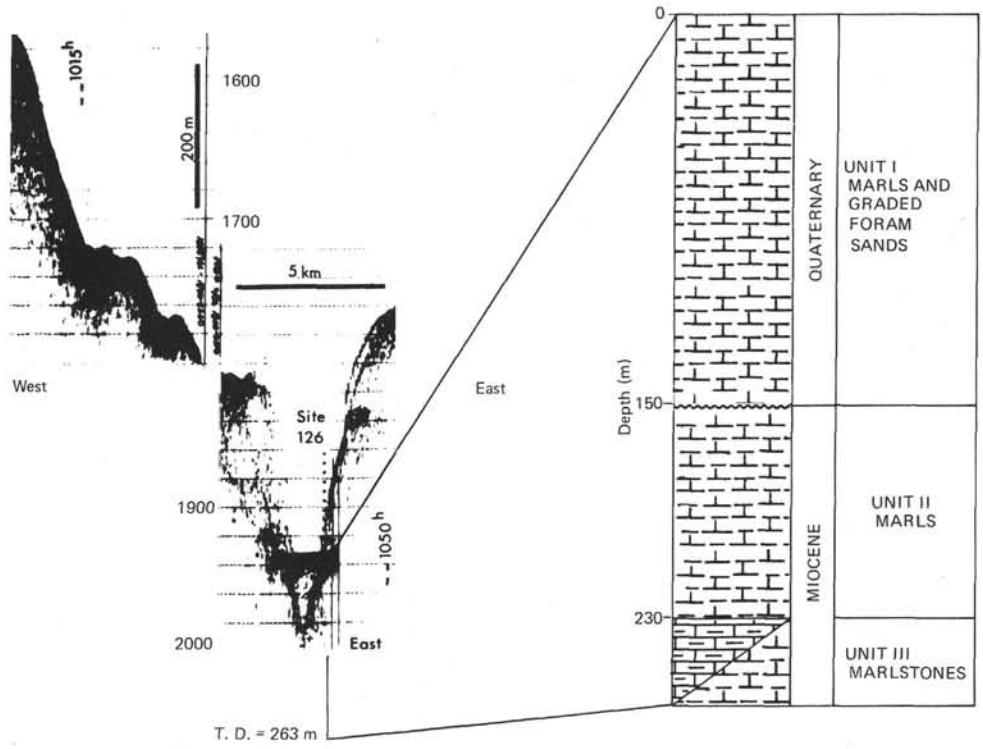

Figure 6. *Correlation of* Glomar Challenger *Seismic reflection profile with drilling results at Site 377.*

bit and the available shiptime (almost certainly less than 500 meters further); (3) The sedimentation rate was so high and the fossil content so poor that we could not hope to obtain much additional information by continued drilling.

The section penetrated and the four cores taken did permit us a glimpse of the sedimentary and structural history of the Mediterranean Ridge.

Three units have been recognized. Unit I is the Quaternary valley-fill and includes nannofossil oozes, marls, sapropels, tephras, sands with graded bedding, and slump breccias. They are similar to those found by the Leg 13 drilling. The valley/cleft is apparently asymmetrical. Our hole was closer to the eastern edge of the valley, but the valley-fill is thicker here (161 m) than that at Hole 126 (108 m) or in Hole 126A (62 m). The contact was easily identified by a marked drilling break.

Unit II consists of nannofossil marls of middle Miocene age. The marls have 30%-50% $CaCO_3$. Both planktonic and benthic foraminifers, as well as nannofossils, are present, although they are very poorly preserved. The presence of benthic foraminifers here at 193 meters subbottom presents a contrast to the Serravallian marls at 62 to 120 meters subbottom in Holes 126 and 126A (see Ryan, Hsü, et al., 1973, p. 225), since the latter were barren. There seems to have been a change towards stagnation prior to the Messinian salinity-crisis, as is indicated by the occurrence of organic-rich sediments.

Unit III is a terrigenous sequence of Miocene (probably early Miocene) age. It consists of organic-rich siltstones, sandstones, and black shales. Both of the samples analyzed for $CaCO_3$ content showed negative results, although nannofossils are found in some smear slides. A few of the siltstones are cross-laminated, similar to those of Serravallian age found in Core 3 at Site 129 on the wall of the Strabo Trench (see Ryan, Hsü et al., 1973, p. 339). However, the siltstones here with associated black shales are more terrigenous. We also noted that the geologic structure beneath this site was similar to that of the Strabo Trench section where dipping beds of middle Miocene age showed evidence of tectonic deformation. At Site 377, dips of up to 30° were observed in laminated sandstones.

The lithology and its sedimentation rate is comparable to deposits usually found on continental rises or in basinal settings, where thick terrigenous clastics accumulate at the present day. We recognized smectite as the dominant clay mineral. This mineral may have come from a volcanic source, but more probably it was brought into the Mediterranean by the Nile. Smectite-rich sediments found farther south at Site 130 and under the Nile Cone belong to the Nile provenance (see Ryan et al., 1973). The findings of smectite here seems to reinforce the hypothesis put forward by Hersey (1965) that the Mediterranean Ridge is an uplifted and deformed wedge of former basinal sediments derived predominantly from the Nile Delta. We failed to find any evidence that the 100-meter sequence penetrated was an olistotrome or a chaotic melange of sediments as suggested by Mülder et al. (1975).

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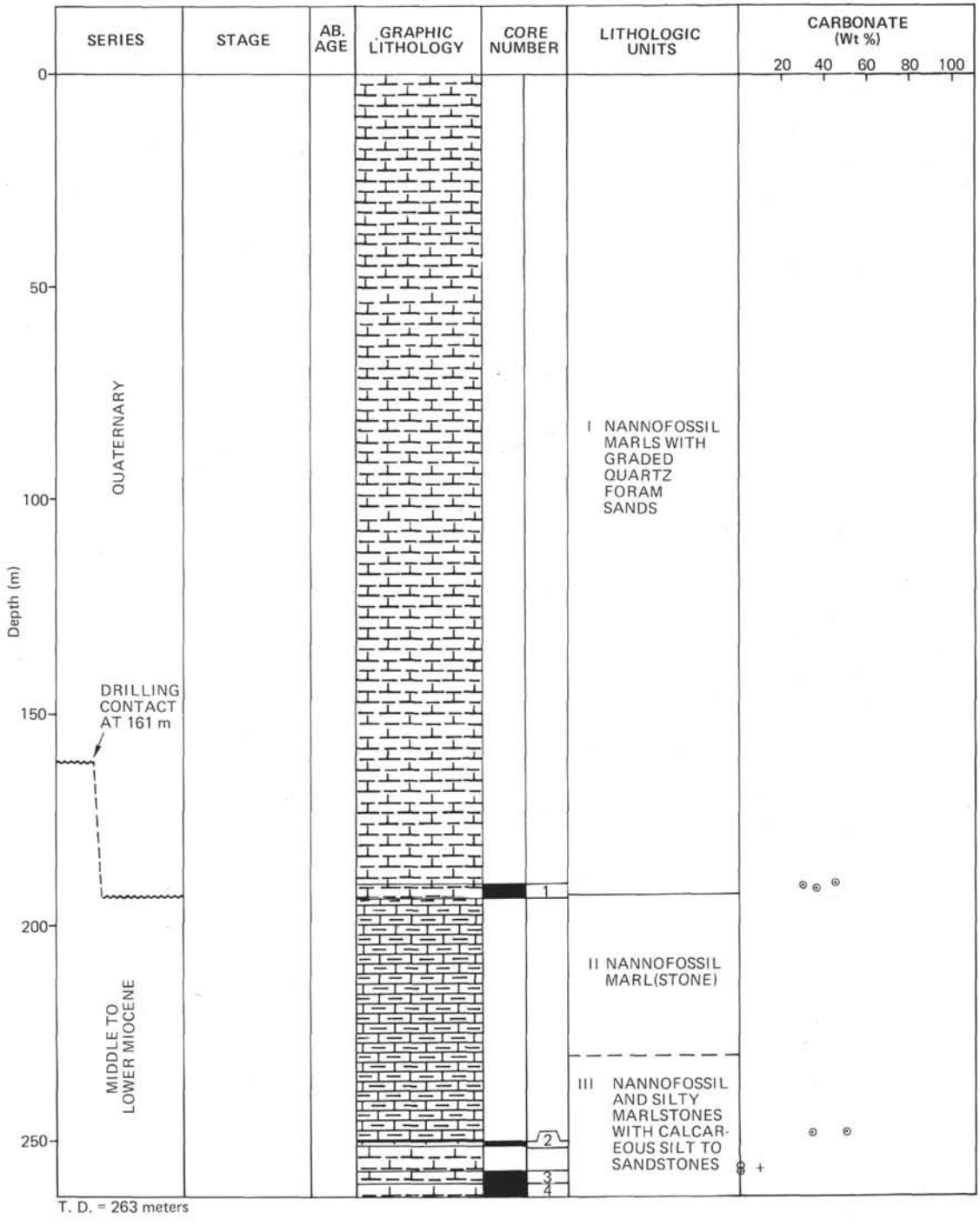
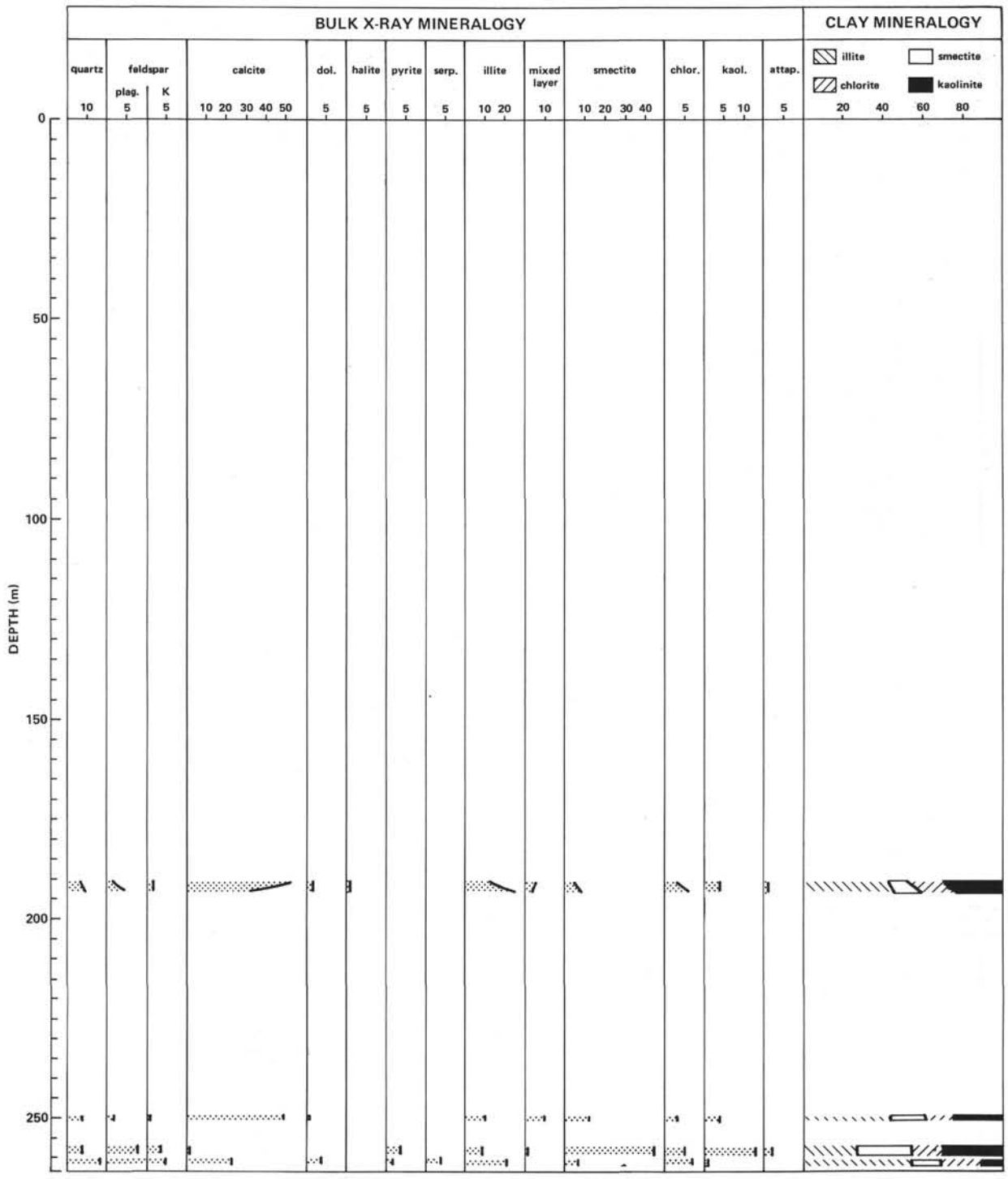
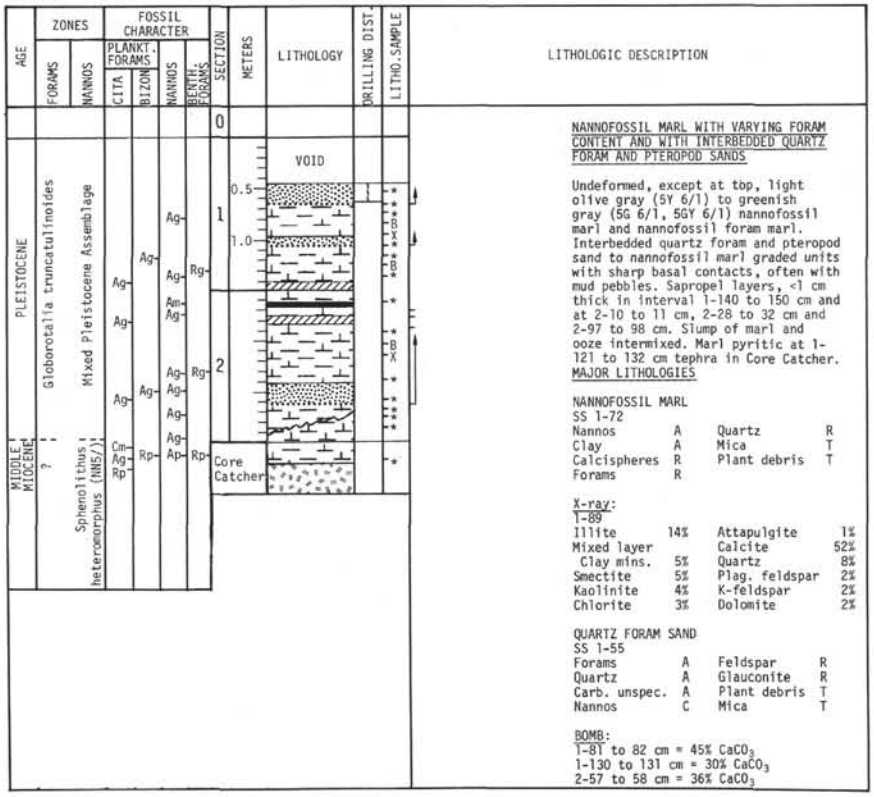

SERIES
STAGE
AB. AGE
GRAPHIC LITHOLOGY
CORE NUMBER
LITHOLOGIC UNITS
CARBONATE (Wt %)
20 40 60 80 100
Depth (m)
0
50
100
150
200
250
QUATERNARY
MIDDLE TO LOWER MIOCENE
DRILLING CONTACT AT 161 m
I NANNOFOSSIL MARLS WITH GRADED QUARTZ FORAM SANDS
II NANNOFOSSIL MARL(STONE)
III NANNOFOSSIL AND SILTY MARLSTONES WITH CALCAREOUS SILT TO SANDSTONES
1
2
3
4
T. D. = 263 meters


BULK X-RAY MINERALOGY
CLAY MINERALOGY
quartz
feldspar
plag.
K
calcite
dol.
halite
pyrite
serp.
illite
mixed layer
smectite
chlor.
kaol.
attap.
illite
smectite
chlorite
kaolinite
DEPTH (m)
0
50
100
150
200
250

Site 377 Hole Core 1 Cored Interval: 190.5-193.5 m



NANNOFOSSIL MARL WITH VARYING FORAM CONTENT AND WITH INTERBEDDED QUARTZ FORAM AND PTEROPOD SANDS

Undeformed, except at top, light olive gray (5Y 6/1) to greenish gray (5G 6/1, 5GY 6/1) nannofossil marl and nannofossil foram marl. Interbedded quartz foram and pteropod sand to nannofossil marl graded units with sharp basal contacts, often with mud pebbles. Sapropel layers, <1 cm thick in interval 1-140 to 150 cm and at 2-10 to 11 cm, 2-28 to 32 cm and 2-97 to 98 cm. Slump of marl and ooze intermixed. Marl pyritic at 1-121 to 132 cm tephra in Core Catcher.

MAJOR LITHOLOGIES

NANNOFOSSIL MARL
SS 1-72

Nannos	A	Quartz	R
Clay	A	Mica	T
Calcispheres	R	Plant debris	T
Forams	R		

X-ray:
1-89

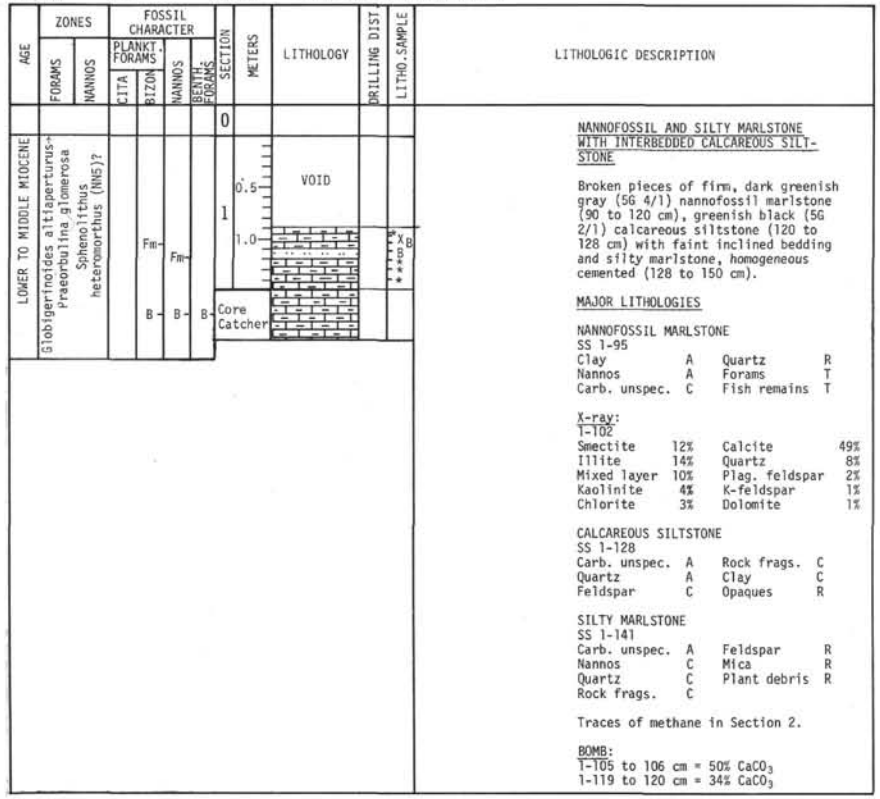
Illite	14%	Attapulgite	1%
Mixed layer Clay mins.	5%	Calcite	52%
Smectite	5%	Quartz	8%
Kaolinite	4%	Plag. feldspar	2%
Chlorite	3%	K-feldspar	2%
		Dolomite	2%

QUARTZ FORAM SAND
SS 1-55

Forams	A	Feldspar	R
Quartz	A	Glauconite	R
Carb. unspec.	A	Plant debris	T
Nannos	C	Mica	T

BOMB:
1-81 to 82 cm = 45% $CaCO_3$
1-130 to 131 cm = 30% $CaCO_3$
2-57 to 58 cm = 36% $CaCO_3$

Site 377 Hole Core 2 Cored Interval: 249.5-250.5 m



NANNOFOSSIL AND SILTY MARLSTONE WITH INTERBEDDED CALCAREOUS SILTSTONE

Broken pieces of firm, dark greenish gray (5G 4/1) nannofossil marlstone (90 to 120 cm), greenish black (5G 2/1) calcareous siltstone (120 to 128 cm) with faint inclined bedding and silty marlstone, homogeneous cemented (128 to 150 cm).

MAJOR LITHOLOGIES

NANNOFOSSIL MARLSTONE
SS 1-95

Clay	A	Quartz	R
Nannos	A	Forams	T
Carb. unspec.	C	Fish remains	T

X-ray:
1-102

Smectite	12%	Calcite	49%
Illite	14%	Quartz	8%
Mixed layer	10%	Plag. feldspar	2%
Kaolinite	4%	K-feldspar	1%
Chlorite	3%	Dolomite	1%

CALCAREOUS SILTSTONE
SS 1-128

Carb. unspec.	A	Rock frags.	C
Quartz	A	Clay	C
Feldspar	C	Opaques	R

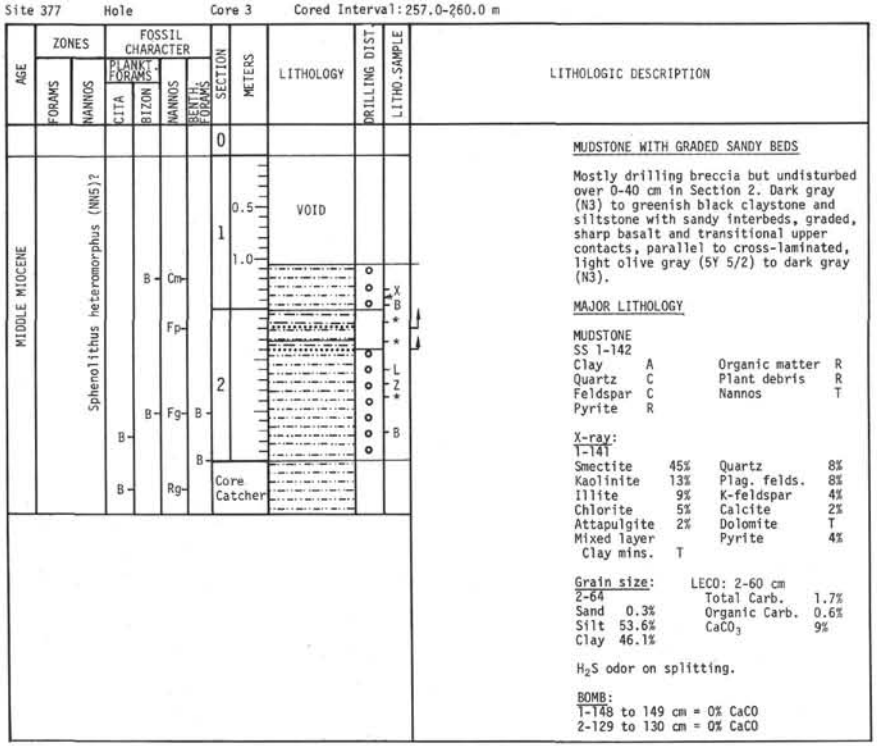
SILTY MARLSTONE
SS 1-141

Carb. unspec.	A	Feldspar	R
Nannos	C	Mica	R
Quartz	C	Plant debris	R
Rock frags.	C		

Traces of methane in Section 2.

BOMB:
1-105 to 106 cm = 50% $CaCO_3$
1-119 to 120 cm = 34% $CaCO_3$

Site 377 Hole Core 3 Cored Interval: 257.0-260.0 m



MUDSTONE WITH GRADED SANDY BEDS

Mostly drilling breccia but undisturbed over 0-40 cm in Section 2. Dark gray (N3) to greenish black claystone and siltstone with sandy interbeds, graded, sharp basalt and transitional upper contacts, parallel to cross-laminated, light olive gray (5Y 5/2) to dark gray (N3).

MAJOR LITHOLOGY

MUDSTONE
SS 1-142

Clay	A	Organic matter	R
Quartz	C	Plant debris	R
Feldspar	C	Nannos	T
Pyrite	R		

X-ray:
1-141

Smectite	45%	Quartz	8%
Kaolinite	13%	Plag. felds.	8%
Illite	9%	K-feldspar	4%
Chlorite	5%	Calcite	2%
Attapulgite	2%	Dolomite	T
Mixed layer		Pyrite	4%
Clay mins.	T		

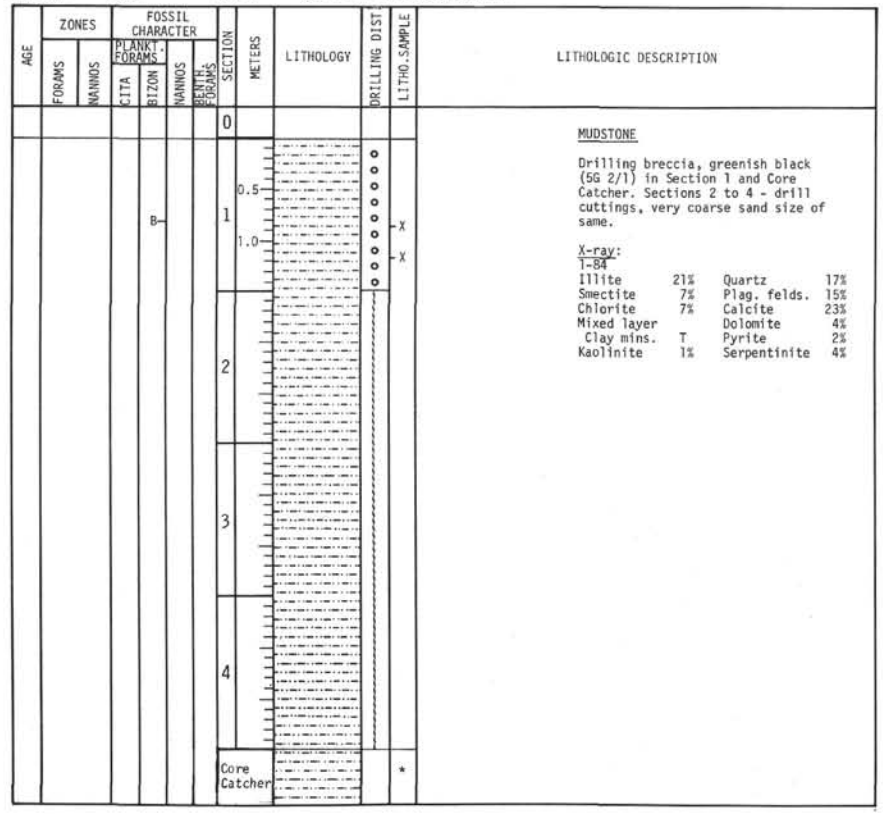
Grain size:
2-64

Sand	0.3%	LECO: 2-60 cm	
Silt	53.6%	Total Carb.	1.7%
Clay	46.1%	Organic Carb.	0.6%
		$CaCO_3$	9%

H_2S odor on splitting.

BOMB:
1-148 to 149 cm = 0% CaCO
2-129 to 130 cm = 0% CaCO

Site 377 Hole Core 4 Cored Interval: 260.0-263.0 m

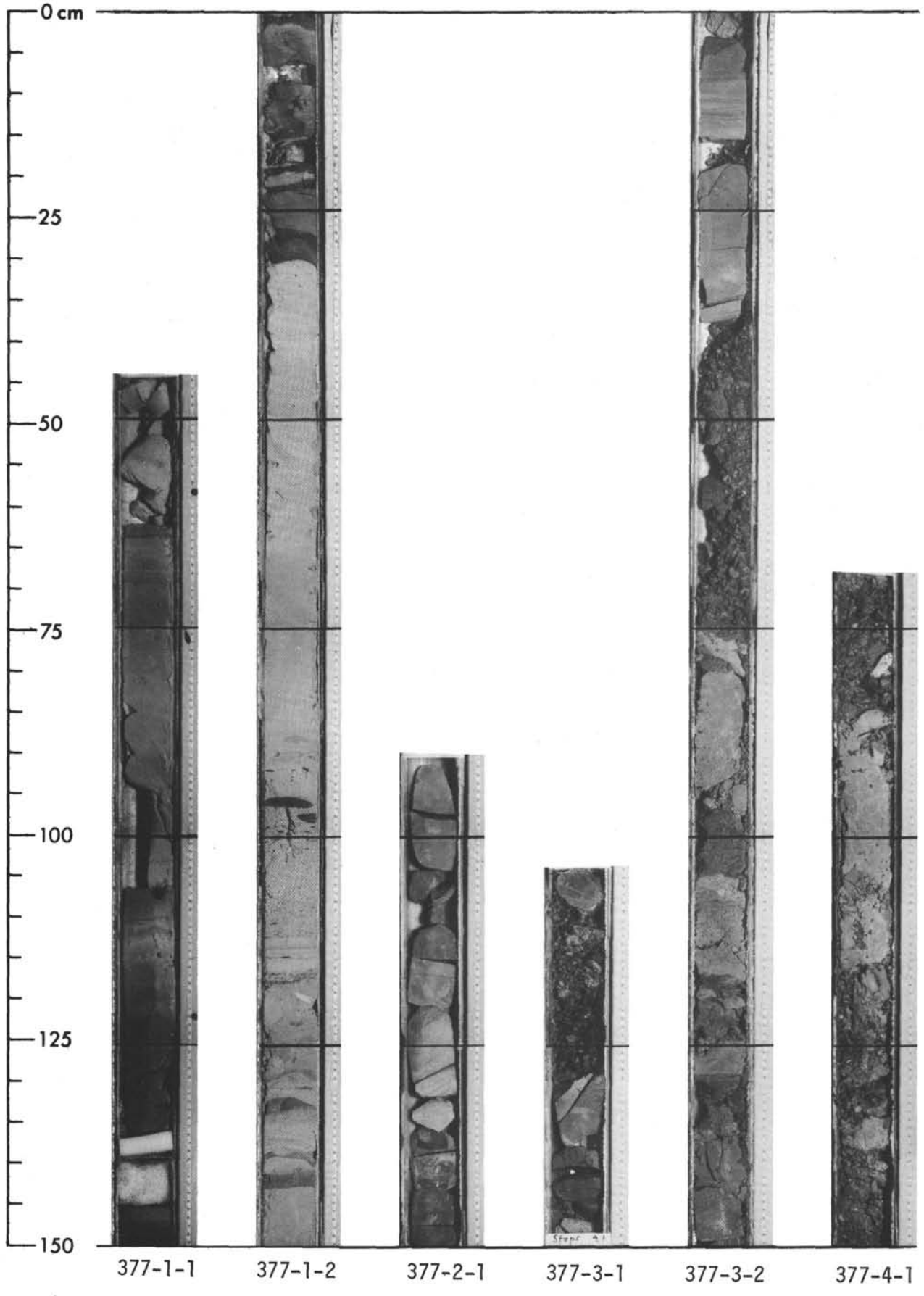


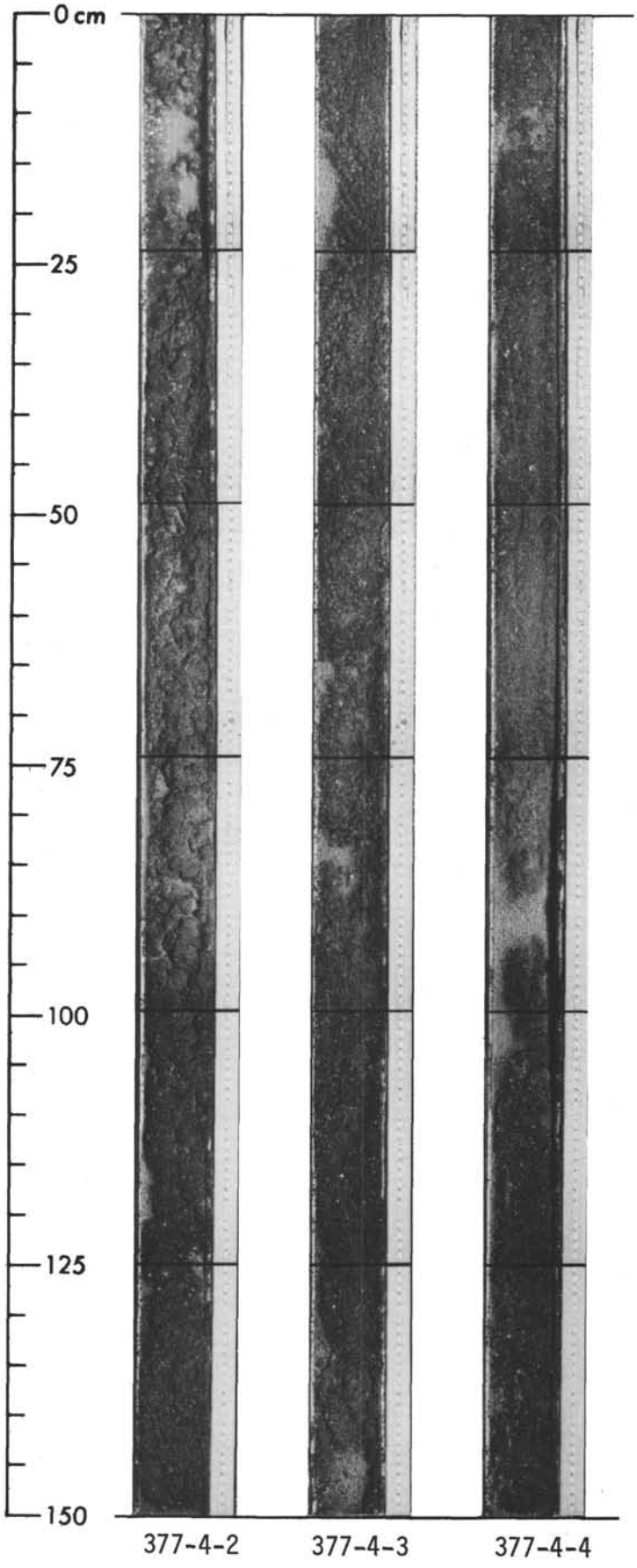
MUDSTONE

Drilling breccia, greenish black (5G 2/1) in Section 1 and Core Catcher. Sections 2 to 4 - drill cuttings, very coarse sand size of same.

X-ray:
1-84

Illite	21%	Quartz	17%
Smectite	7%	Plag. felds.	15%
Chlorite	7%	Calcite	23%
Mixed layer		Dolomite	4%
Clay mins.	T	Pyrite	2%
Kaolinite	1%	Serpentinite	4%


0 cm
25
50
75
100
125
150
377-1-1
377-1-2
377-2-1
377-3-1
377-3-2
377-4-1


0 cm
25
50
75
100
125
150
377-4-2
377-4-3
377-4-4